The Long-Term Effects of Maternal Postnatal Depression on a Child's Intelligence Quotient:

A Meta-Analysis of Prospective Cohort Studies Based on 974 Cases

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ABSTRACT

Objective: Epidemiologists have explored the relationship between maternal postnatal depression (PND) and the intelligence quotient (IQ) of the resulting offspring, but the results remain inconclusive. This study aims to analyze the literature regarding the association between maternal PND and a child's IQ.

Data Sources: A search of articles in PubMed, Web of Science, and MEDLINE databases from inception to September 2015 was conducted and supplemented by a manual search of relevant reference lists. The following search terms were used: (*postpartum* OR *postnatal* OR *puerperal*) AND (*depression* OR *depressive symptoms* OR *blues* OR *dysthymia* OR *disorders* OR *psychosis*) AND (*intelligence quotient* OR *IQ* OR *intelligence tests* OR *intelligence* OR *cognitive* OR *cognition*) AND (*children* OR *child* OR *adolescent* OR *offspring*) AND (*cohort* OR *prospective* OR *follow-up* OR *follow* OR *longitudinal*).

Study Selection: Articles exploring the association between maternal PND and IQ of offspring aged 2 years and older were included. A total of 510 records were retrieved.

Data Extraction: Two authors independently selected eligible studies and extracted data. Three authors assessed the quality of the studies. To explore the associations between maternal PND and full IQ and verbal IQ, random-effects meta-analyses were performed, followed by subgroup analysis of impact on full IQ.

Results: Nine articles were eligible for review. On the basis of the Newcastle-Ottawa Scale, 7 studies were considered to be of high quality. When one study of participants aged 3.8 years was excluded from the meta-analysis, the pooled weighted mean difference of full IQ between the children of PND mothers and non-PND mothers was −4.086 (95% CI, −6.578 to −1.594), and the pooled standard mean difference of verbal IQ between the children of PND mothers and non-PND mothers was −0.361 (95% CI, −0.564 to −0.158). Subgroup analysis showed that the child's age at evaluation, diagnostic method of PND, study quality, and socioeconomic status did not affect the mean difference in full IQ between children of PND mothers and those of non-PND mothers. When the excluded study was included in the meta-analysis, the results did not vary.

Conclusions: Maternal PND may be a risk factor for a child's lower IQ. More studies of high methodological quality may be needed.

J Clin Psychiatry 2016;77(11):e1474–e1482
dx.doi.org/10.4088/JCP.15r10124

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Postnatal depression (PND) can be defined as an episode of nonpsychotic depression according to a validated or standardized measure, with an onset within 1 year of childbirth.[1,2] Postnatal depression is a considerable public health problem, with an incidence of approximately 10%–20% in postpartum mothers.[3,4] It not only affects women but also can negatively impact the child. Research has shown that maternal PND is associated with a child's emotional and behavioral problems and affects mother-infant interaction and the child's physical growth.[5–7] Moreover, a number of observational studies have found that maternal PND is associated with the child's cognitive outcomes. The first postnatal year may represent a sensitive period during which maternal depression can be associated with brain development.[8] Postnatal depression may be associated with an infant's distress and lack of synchrony between the infant's actions and maternal responses.[9–11] Distress is defined as "an aversive state in which a person is unable to adapt completely to stressors and their resulting stress and shows maladaptive behaviors."[12(p4–5)] An infant's distress and the lack of synchrony between the infant and mother have been shown to be interrelated: infants of PND mothers who are withdrawn are more likely to be distressed,[13] and mothers of distressed infants are more likely to be less responsive to the infant.[14] Lack of synchrony between the infant and mother may have a negative impact on subsequent learning.[15] In addition, an infant's distress, which may be caused by maternal PND, may also interfere with learning.[16] Finally, negative effects on learning from infant distress and lack of mother-child synchrony may have long-term consequences on cognitive development.[8]

The intelligence quotient (IQ) is an important indicator of cognitive outcome. Since IQ is a commonly used measure and is very comparable between studies, many studies exploring the association between maternal PND and a child's cognitive function have chosen to use IQ as the measure of cognition.[17] Some studies have demonstrated a significantly negative association between maternal PND and the child's IQ. For example, Milgrom et al[18] found that children of PND mothers scored lower on full IQ tests; Hay et al[19] also found that PND was negatively associated with full

Clinical Points

- Previous studies exploring the association between maternal postnatal depression and a child's intelligence quotient remain inconclusive.
- Postnatal depression may be a risk factor for a child's lower intelligence quotient, and children of mothers with postnatal depression may be listed as high risk so that they may receive potential intervention.

IQ. However, the results of other studies imply that PND has had inconsistent associations with IQ. Kurstjens and Wolke[20] found no difference in full IQ between children of PND mothers and those of non-PND mothers; Murray et al[21] failed to find an adverse association between PND and full IQ. This variability in the included studies may result from the relatively small sample sizes in most studies, differences in socioeconomic status (SES) of study populations, and variability in study quality.[20] Considering this divergence, a new prospective cohort study with a large sample size is needed. However, this kind of study is both costly and lengthy. Thus, an economical and efficient alternative is to perform a meta-analysis of the current evidence. In this study, we focused on IQ as a cognitive outcome, because IQ tests usually generate standardized scores that may be very comparable across different studies and different age groups.[17] As a result, we conducted the first meta-analysis that explores the association between maternal PND and the child's IQ.

METHODS

Study Design

A meta-analysis of current epidemiologic studies was performed according to the meta-analysis of observational studies in epidemiology (MOOSE).[22] We retrieved articles from PubMed, Web of Science, and MEDLINE. We also manually screened relevant reference lists to identify potentially related studies. The procedures were approved by the Ethics Committee on Human Experimentation of China Medical University.

Inclusion and Exclusion Criteria

Studies were included if they (1) were prospective cohort studies; (2) reported the sample size, mean, 95% confidence interval (CI), and standard deviation (SD) or standard error (SE) of IQ among children of PND mothers and non-PND mothers; and (3) were written in English. Kopp and McCall[23] reported that infant IQ did not predict later IQ until the infant had reached 18 or 24 months of age, since tests of infants younger than that age emphasize sensorimotor skills and have less emphasis on tasks involving cognitive processes such as language. To explore the association between maternal PND and a child's IQ, we focused on children 2 years of age and older. Therefore, IQs of enrolled subjects 2 years of age or older were included. Case reports and comments were excluded.

Search Strategy

We performed an electronic search from database inception to September 2015 and used the terms, (*postpartum* OR *postnatal* OR *puerperal*) AND (*depression* OR *depressive symptoms* OR *blues* OR *dysthymia* OR *disorders* OR *psychosis*) AND (*intelligence quotient* OR *IQ* OR *intelligence tests* OR *intelligence* OR *cognitive* OR *cognition*) AND (*children* OR *child* OR *adolescent* OR *offspring*) AND (*cohort* OR *prospective* OR *follow-up* OR *follow* OR *longitudinal*). Relevant references found manually supplemented the results.

Data Extraction

Information from eligible studies was extracted independently by 2 experienced authors (G.S. and Guangying Liu). Included information was as follows: first author's name, study location, published year, the child's age at evaluation, result of IQ test, depression classification, timing of PND assessment, confounders, SES, and detailed information on IQ. Disagreements were solved by discussion among all authors. Adjusted IQ estimates were always preferred.

Statistical Analysis

Mean and SD values were applied to evaluate the association between maternal PND and the child's IQ. The studies included in the meta-analysis may have used different instruments. If the scales of measurements differed from study to study, standard mean differences (SMDs) were used. If the scales of measurements were the same, then weighted mean differences (WMDs) were used.[24] Full IQ scores from all eligible studies were obtained from comparable measurements (normative data had a mean [SD] of 100 [15]). Therefore, the WMDs were pooled to evaluate the difference in full IQ between children of PND mothers and those of non-PND mothers (WMD = the difference between the mean score of the children of PND mothers and that of children of non-PND mothers). For verbal IQ, the mean (SD) of normative data from McCarthy IQ Scales[25] is 50 (10); the mean (SD) of normative data from other measurements is 100 (15). Therefore, the SMDs were pooled from eligible studies to evaluate the difference in verbal IQ between children of PND mothers and those of non-PND mothers (SMD = the difference between the mean score of children of PND mothers and that of non-PND mothers divided by the pooled SDs of the 2 groups). Standard mean difference is considered as small (approximately 0.2), medium (approximately 0.5), or large (approximately 0.8).[26]

The degree of heterogeneity (study-to-study variation) between eligible studies was examined by Q statistics. Meta-analysis was performed using a random-effects model. Subgroup analysis is a way to explore the source of heterogeneity.[24] In this study, we performed subgroup analysis on full IQ based on the child's age at evaluation, study quality (low quality and high quality), diagnostic method of PND (structured interview and written self-report), and SES. As to the child's age at evaluation, we defined "2–3 years old," "3–5 years old," and "5–11 years old" as "toddler," "preschooler,"

and "school-aged child," respectively. As to the proportion of the samples from middle and high SES, we defined "> 50%" and "≤ 50%" as "middle and high SES group" and "low SES group," respectively. Sensitivity analysis was performed to test the robustness of the pooled results. It tests whether the conclusions might differ substantially if a single study were omitted.[24] When performing sensitivity analysis, we omitted each study at 1 time, pooled the other studies to get new results, and then compared the differences between new results and results pooled from all studies. If no results varied significantly, we could say that the conclusion was stable. A funnel plot is a graph created to test the existence of publication bias. The funnel plot was plotted with effect size (WMD or SMD) on the x-axis and the SE on the y-axis. Dots represent the eligible studies. If no publication bias exists, the largest studies will be near the average (middle of the funnel), and smaller studies will be plotted symmetrically—a funnel-shaped distribution appears. Asymmetric plots might indicate the existence of publication bias. Egger test is a common way to interpret asymmetry of funnel plots and uses a linear regression approach.[24] Due to the limited number of studies, the statistical power of tests is usually limited. Therefore, $P < .1$ was considered to represent the existence of publication bias. A 2-tailed probability (P) value of < .05 was considered to be statistically significant. Meta-analysis was performed using Stata V.10.0 (StataCorp LP).

Quality Assessment

Qualities of included studies were assessed independently by 3 authors (Guangying Liu, G.S., and B.P.) using the Newcastle-Ottawa Scale[27] for cohort studies. This scale consists of an 8-item instrument and assesses the selection of patients and controls and comparability of those 2 groups, and it demonstrates the exposure or outcome of interest.[27] The range for this scale is 0 to 9. Disagreements were solved by discussion between the 3 authors. We defined "Newcastle-Ottawa Scale score < 7" and "Newcastle-Ottawa Scale score ≥ 7" as "low quality" and "high quality," respectively.[28]

RESULTS

Characteristics of Eligible Studies

A total of 510 articles (99 from PubMed, 320 from Web of Science, and 91 from MEDLINE) were found in an electronic search. A total of 457 articles were excluded due to irrelevance. Another 46 articles were excluded for duplicates (28), reviews (5), evaluation of child aged less than 2 years (5), and incomplete or no data on cognitive outcomes (8). In addition, we manually added 2 relevant articles.[29,30] Therefore, 9 articles[18–21,29–33] were eligible for review (Figure 1). Four articles[18,19,21,31] reported the full IQ and verbal IQ. Three articles[20,30,33] reported only the full IQ, and 2 articles[29,32] reported only the verbal IQ. Results of the quality assessment (see Supplementary eTable 1) indicate that 7 were high-quality studies (Newcastle-Ottawa Scale scores ≥ 7).[19–21,29,31–33] In these articles, 5 studies[19,21,30,31,33] were performed in the United Kingdom, 2 studies[18,32] in Australia, 1 article[20] in Germany, and 1 study[29] in the Netherlands. The sample sizes of the PND mothers ranged from 21 to 660, and the sample sizes of the non-PND mothers ranged from 30 to 4,369. Postnatal depression was diagnosed by structured interview in 7 studies,[18–21,31–33] and only 1 study[30] used a written self-report (Edinburgh Postnatal Depression Scale score > 12). One study[29] used both structured interviews and written self-reports (Beck Depression Inventory ≥ 14). Ages of children ranged from 3.5 years old to 11 years old. Most participants in all studies had middle and high SES.[20,21,30,31] Three studies[18,29,32] did not report the SES of participants. The study by Hay et al[19] and the study by Sharp et al[33] were from the same cohort (South London, United Kingdom). Most participants from the studies by Hay et al[19] and Sharp et al[33] were from low SES. Hay and colleagues[19] presented the mean (95% CI) of full IQ adjusted for conduct problems. Kersten-Alvarez et al[29] presented the mean (SE) of verbal IQ adjusted for child's age, child's gender, and risk factors of maternal education, presence of partner conflict, separation from father, and number of stressful life events. In other studies, the mean (SD) values were not adjusted for by any confounders. In the study by Murray et al,[21] mothers were primiparous, and healthy full-term infants had a birth weight > 2.5 kg (5.5 lb). In the studies by Evans et al[30] and Kurstjens and Wolke,[20] singleton infants were included. In the studies by McMahon et al[32] and Hay and Kumar[31] (North London), infants were first born. For the studies by Murray et al,[21] Kurstjens and Wolke,[20] Hay et al,[19] and McMahon et al,[32] we calculated the effect from available data. The details of the eligible studies are presented in Table 1.

Figure 1. Flow Diagram of Study Identification

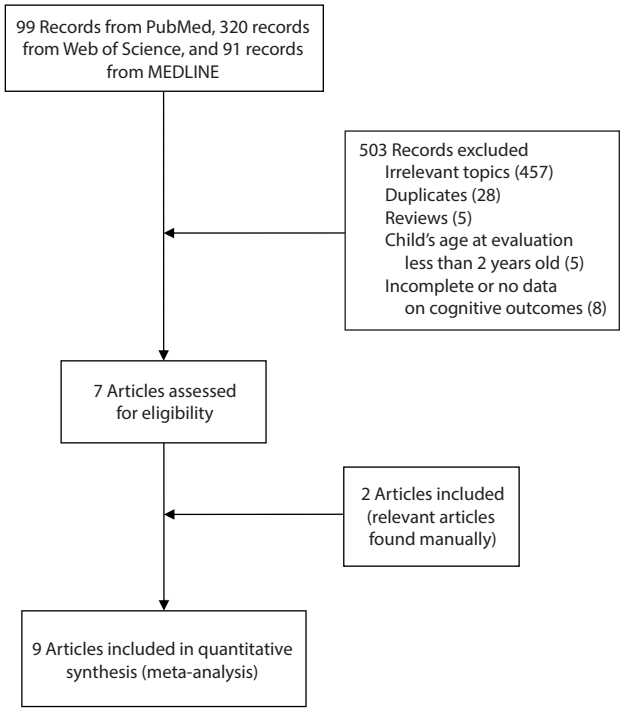

Table 1. Information Abstracted From 9 Studies Exploring the Association Between Maternal Postnatal Depression and IQ of Offspring

Study	Study Location	Published Year	Age of Child, y	IQ Test	Depression Classification	Timing of Assessment	Study Characteristics	Socioeconomic Status, %[a]	Children of Mothers With Postnatal Depression			Children Mothers Without Postnatal Depression		
									n	Full IQ, Mean (SD)	Verbal IQ, Mean (SD)	n	Full IQ, Mean (SD)	Verbal IQ, Mean (SD)
Milgrom et al[18]	Victoria, Australia	2004	3.5	WPPSI-R	Clinical diagnosis	15.8 wk[b]	NR	NR	23	106.56 (9.83)	107.35 (14.34)	33	113.16 (12.06)	113.16 (12.06)
Kurstjens and Wolke[20]	Germany	2001	6.3	MPC	SADS	6.3 y	Enrolled: singleton infants	63.70	43	95.5 (12.0)	NR	762	96.8 (12.1)	NR
Murray et al[21]	Cambridge, United Kingdom	1996	5	MIQS	SPI	5–6 wk and 8–10 wk	Matching: gender Enrolled: primiparous mothers, healthy full-term infants having a birth weight > 2.5 kg (5.5 lb)	65	54	110.8 (12.5)	57.8 (10.4)	40	113.1 (11.4)	58.2 (9.0)
Evans et al[30]	Avon, United Kingdom	2012	8	WISC-III	EPDS >12	8 wk and 8 mo	Enrolled: singleton infants	63	660	103.79 (15.72)	NR	4,369	106.15 (15.60)	NR
Sharp et al[33]	South London, United Kingdom	1995	3.8	MIQS	CIS or SADS	3 mo and 12 mo and 4 y	NR	NR	60	94.0 (17.0)	NR	75	100.6 (13.6)	NR
Hay et al[19]	South London, United Kingdom	2001	11	WISC-III	CIS	3 mo	Confounder: conduct problems	11	29	90.31 (16.15)	90.6 (14.9)	103	99.75 (17.25)	100.3 (16.9)
Hay and Kumar[31]	North London, United Kingdom	1995	4	MIQS	Standardized semistructured interview	12 mo	Enrolled: first-born children	79	21	105.0 (14.5)	53.7 (10.1)	71	114.8 (12.0)	58.3 (8.8)
McMahon et al[32]	Australia	2008	4.2	WPPSI-R	CIDI	4 mo	Enrolled: first-born children	NR	55	NR	107.85 (9.91)	30	NR	113.97 (11.66)
Kersten-Alvarez et al[29]	Netherlands	2012	5.4[b]	PPTV-R	Clinical diagnosis and BDI ≥14	12 mo	Confounders: child age, child gender, risk factors of maternal education, presence of partner conflict, separation from father, and number of stressful life events	NR	29	NR	105.73 (24.12)	113	NR	108.24 (19.88)

[a]Proportion of study participants with middle and high socioeconomic status. [b]Value represents mean.

Abbreviations: BDI = Beck Depression Inventory, CIDI = Composite International Diagnostic Interview, CIS = Clinical Interview Schedule, EPDS = Edinburgh Postnatal Depression Scale, IQ = intelligence quotient, MIQS = McCarthy IQ Scales, MPC = Mental Processing Composite, NR = not reported, PPTV-R = Peabody Picture Vocabulary Test-Revised, SADS = Schedule for Affective Disorders and Schizophrenia, SPI = Standard Psychiatric Interview, WISC-III = Wechsler Intelligence Scale for Children-III, WPPSI-R = Wechsler Preschool and Primary Scale of Intelligence-Revised.

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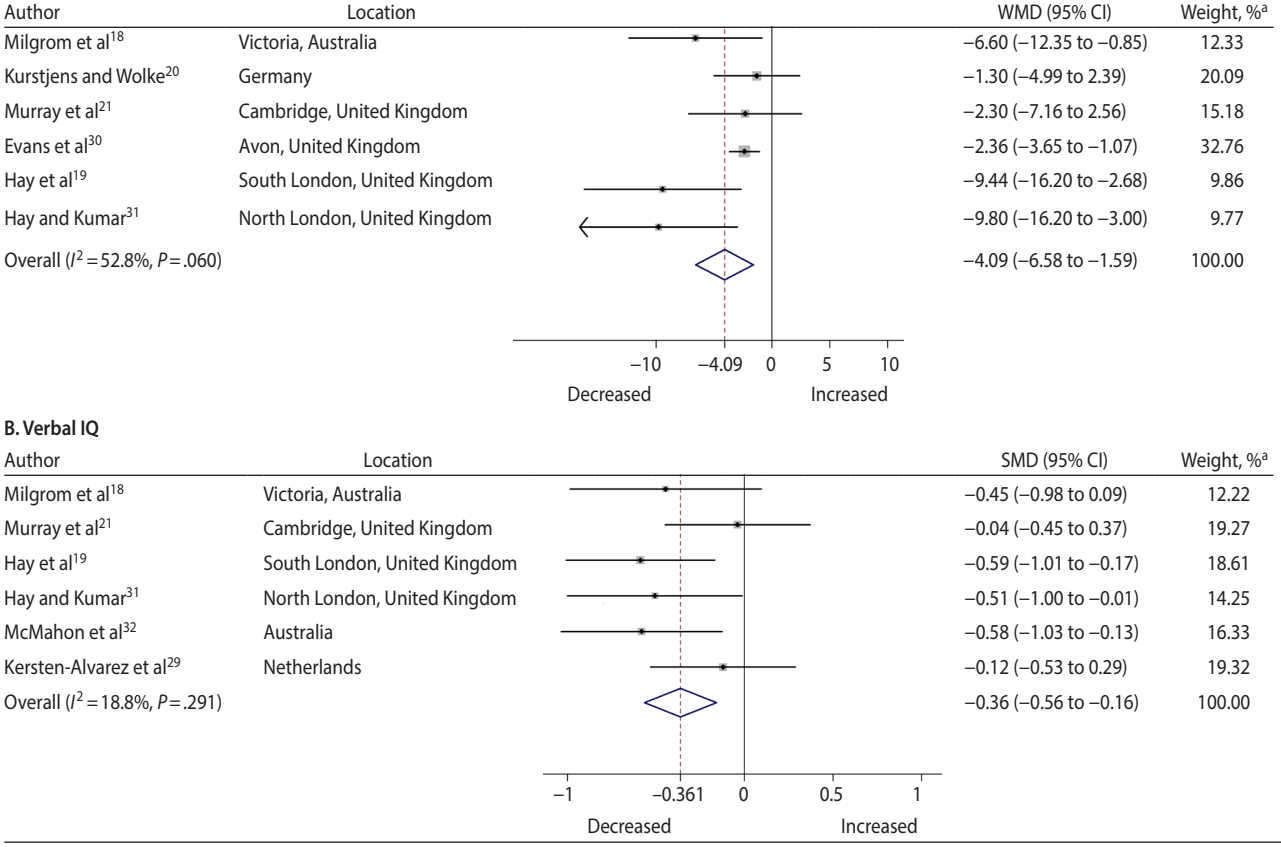
Figure 2. Forest Plots of the Associations Between Maternal Postnatal Depression and Full IQ and Verbal IQ Among Children[a]



[a]The dashed line in parts A and B represents the overall meta-analyzed measure of effect. [b]Weights are from random effects analysis.
Abbreviations: IQ = intelligence quotient, SMD = standard mean difference, WMD = weighted mean difference.

Results of the Meta-Analysis

When the study by Sharp et al[33] was not included in the meta-analysis, the children of PND mothers scored significantly lower on full IQ than those of non-PND mothers (WMD = −4.086; 95% CI, −6.578 to −1.594; P = .001). The test of heterogeneity across these studies was marginally significant (I^2 = 52.8%, P = .06; Figure 2A). After the study by Sharp et al[33] was added, the children of PND mothers scored significantly lower than those of non-PND mothers (WMD = −4.384; 95% CI, −6.715 to −2.053; P = .001). The test of heterogeneity across these studies was marginally significant (I^2 = 51.9%, P = .052; Supplementary eFigure 1). In verbal IQ, the results of the random-effects meta-analysis reported the SMD between the children of PND mothers and those of non-PND mothers was −0.361 (95% CI, −0.564 to −0.158; P < .001). The test for heterogeneity was not significant (I^2 = 18.8%, P = .29; Figure 2B).

Subgroup Analysis

In subgroup analysis, when the study by Sharp et al[33] was not included in the meta-analysis, the results of the middle and high SES group (WMD = −2.787; 95% CI, −5.012 to −0.561) were not significantly different compared to those of the low SES group (WMD = −9.44; 95% CI, −16.196 to −2.684), although the risk of both groups was significant (Figure 3A). After the study by Sharp et al[33] was added, the results did not vary (Supplementary eFigure 2).

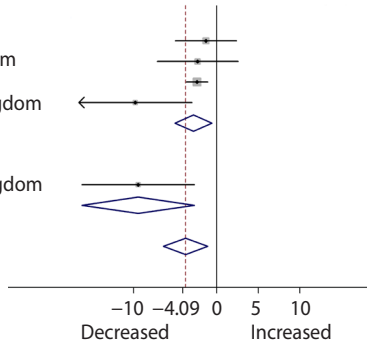
Because the eligible studies in our analysis did not have children ranging from 2 to 3 years old (toddler group), there were only 2 subgroups: preschoolers and school-aged children. When the study by Sharp et al[33] was not included in the meta-analysis, in a subgroup classified by the child's age at evaluation (preschoolers or school-aged children), the results of the preschoolers group (WMD = −5.735; 95% CI, −10.015 to −1.455) were not significantly different from those of the school-aged children group (WMD = −3.068; 95% CI, −6.047 to −0.089), although the risk of each of the 2 groups was significant (Figure 3B). After the study by Sharp et al[33] was added, the results of the preschoolers group (WMD = −5.809; 95% CI, −8.812 to −2.806) were not significantly different from those of the school-aged children group (WMD = −3.068; 95% CI, −6.047 to −0.089), although the risk of each of the 2 groups was significant (Supplementary eFigure 3).

When the study by Sharp et al[33] was not included in the meta-analysis, in a subgroup classified by study quality (low quality or high quality), the result of the low quality group (WMD = −3.516; 95% CI, −7.216 to 0.185) was not significantly different from that of the high quality group (WMD = −4.976; 95% CI, −9.273 to −0.679), the risk of the

Figure 3. Associations Between Maternal Postnatal Depression and Full IQ Among Children: Subgroup Analysis[a]

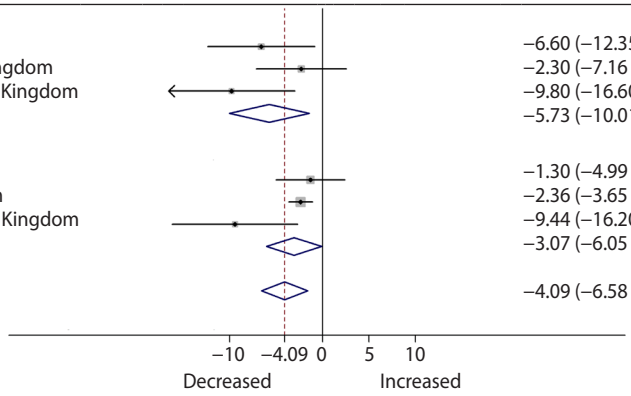
A. Socioeconomic Status

Study	Location	WMD (95% CI)	Weight, %[a]
Middle and high socioeconomic status			
Kurstjens and Wolke[20]	Germany	−1.30 (−4.99 to 2.39)	22.94
Murray et al[21]	Cambridge, United Kingdom	−2.30 (−7.16 to 2.56)	17.38
Evans et al[30]	Avon, United Kingdom	−2.36 (−3.65 to −1.07)	37.13
Hay and Kumar[31]	North London, United Kingdom	−9.80 (−16.60 to −3.00)	11.22
Subtotal (I^2 = 38.5%, P = .181)		−2.79 (−5.01 to −0.56)	88.67
Low socioeconomic status			
Hay et al[19]	South London, United Kingdom	−9.44 (−16.20 to −2.68)	11.33
Subtotal		−9.44 (−16.20 to −2.68)	11.33
Overall (I^2 = 54.8%, P = .065)		−3.74 (−6.42 to −1.07)	100.00



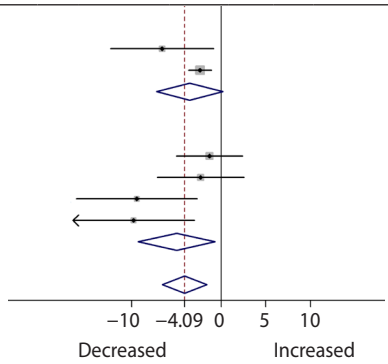
B. Child's Age at Evaluation

Study	Location	WMD (95% CI)	Weight, %[a]
Preschooler			
Milgrom et al[18]	Victoria, Australia	−6.60 (−12.35 to −0.85)	12.33
Murray et al[21]	Cambridge, United Kingdom	−2.30 (−7.16 to 2.56)	15.18
Hay and Kumar[31]	North London, United Kingdom	−9.80 (−16.60 to −3.00)	9.77
Subtotal (I^2 = 40.1%, P = .188)		−5.73 (−10.01 to −1.46)	37.28
School-aged children			
Kurstjens and Wolke[20]	Germany	−1.30 (−4.99 to 2.39)	20.09
Evans et al[30]	Avon, United Kingdom	−2.36 (−3.65 to −1.07)	32.76
Hay et al[19]	South London, United Kingdom	−9.44 (−16.20 to −2.68)	9.86
Subtotal (I^2 = 55.6%, P = .105)		−3.07 (−6.05 to −0.09)	62.72
Overall (I^2 = 52.8%, P = .060)		−4.09 (−6.58 to −1.59)	100.00



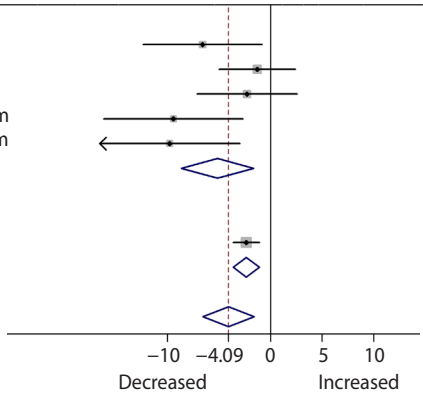
C. Study Quality

Study	Location	WMD (95% CI)	Weight, %[a]
Low quality			
Milgrom et al[18]	Victoria, Australia	−6.60 (−12.35 to −0.85)	12.33
Evans et al[30]	Avon, United Kingdom	−2.36 (−3.65 to −1.07)	32.76
Subtotal (I^2 = 49.7%, P = .158)		−3.52 (−7.22 to 0.18)	45.09
High quality			
Kurstjens and Wolke[20]	Germany	−1.30 (−4.99 to 2.39)	20.09
Murray et al[21]	Cambridge, United Kingdom	−2.30 (−7.16 to 2.56)	15.18
Hay et al[19]	South London, United Kingdom	−9.44 (−16.20 to −2.68)	9.86
Hay and Kumar[31]	North London, United Kingdom	−9.80 (−16.60 to −3.00)	9.77
Subtotal (I^2 = 61.5%, P = .050)		−4.98 (−9.27 to −0.68)	54.91
Overall (I^2 = 52.8%, P = .060)		−4.09 (−6.58 to −1.59)	100.00



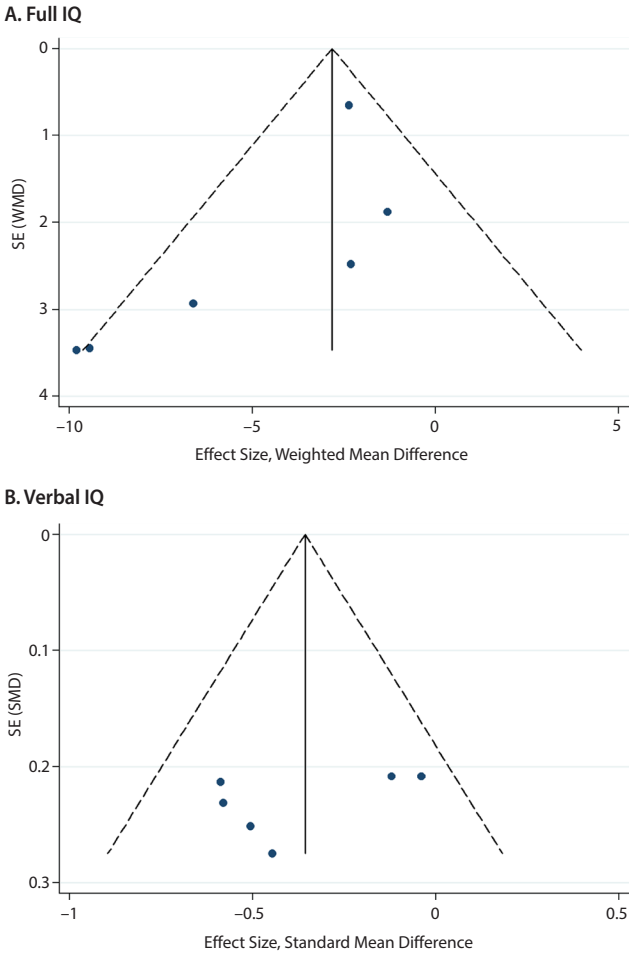
D. Diagnostic Method of Postnatal Depression

Study	Location	WMD (95% CI)	Weight, %[a]
Structured interview			
Milgrom et al[18]	Victoria, Australia	−6.60 (−12.35 to −0.85)	12.33
Kurstjens and Wolke[20]	Germany	−1.30 (−4.99 to 2.39)	20.09
Murray et al[21]	Cambridge, United Kingdom	−2.30 (−7.16 to 2.56)	15.18
Hay et al[19]	South London, United Kingdom	−9.44 (−16.20 to −2.68)	9.86
Hay and Kumar[31]	North London, United Kingdom	−9.80 (−16.60 to −3.00)	9.77
Subtotal (I^2 = 53.2%, P = .074)		−5.17 (−8.68 to −1.65)	67.24
Written self-report			
Evans et al[30]	Avon, United Kingdom	−2.36 (−3.65 to −1.07)	32.76
Subtotal		−2.36 (−3.65 to −1.07)	32.76
Overall (I^2 = 52.8%, P = .060)		−4.09 (−6.58 to −1.59)	100.00



[a]The dashed line in parts A through D represents the overall meta-analyzed measure of effect. [b]Weights are from random effects analysis.
Abbreviations: IQ = intelligence quotient, WMD = weighted mean difference.

Figure 4. Funnel Plots With Pseudo 95% CLs for Eligible Studies in Full IQ and Verbal IQ



low quality group was not significant, and the risk of the high quality group was significant. After the study by Sharp et al[33] was added, the results did not vary (Supplementary eFigure 4).

When the study by Sharp et al[33] was not included in the meta-analysis, in a subgroup classified by diagnostic method of PND (structured interview and written self-report), the result of the structured interview group (WMD = −5.166; 95% CI, −8.681 to −1.650) was not significantly different from that of the written self-report group (WMD = −2.360; 95% CI, −3.645 to −1.075), and the risk of both groups was significant (Figure 3D). After the study by Sharp et al[33] was added, the results did not vary (Supplementary eFigure 5).

Sensitivity analyses showed that both the pooled WMD for full IQ and the pooled SMD for verbal IQ were stable, which indicated that our results were reliable. When the study by Sharp et al[33] was not included in the meta-analysis, the results were not significant using Egger test (full IQ, $P = .108$; verbal IQ, $P = .322$), but the funnel plots for full IQ (Figure 4A) and verbal IQ (Figure 4B) seemed asymmetric. When the study by Sharp et al[33] was included in the meta-analysis, the result was significant ($P = .049$) for the Egger test for full IQ, and the funnel plots for full IQ seemed asymmetric (Supplementary eFigure 6).

DISCUSSION

This study is the first meta-analysis to explore the association between maternal PND and a child's IQ. It reports that children of PND mothers had lower verbal and full IQ scores than children of non-PND mothers. The pooled SMD of the verbal IQ scores between children of PND mothers and those of non-PND mothers was 0.361, which was a small to medium effect size based on the view from Cohen.[26] Therefore, children of PND mothers may be listed as a high-risk population, and interventions may be performed to make up for the negative effect of maternal PND on the child's IQ.

There are 2 reasons that can account for the negative relationship between maternal PND and the child's IQ. First, maternal depression within 1 year of childbirth may influence the infant's electrical brain activity. According to studies,[34,35] infants of non-PND mothers are more likely to exhibit left frontal electrical activity, whereas infants of PND mothers exhibit right frontal electrical activity. Left and right frontal electrical activities have been shown to relate to normal action and distress, respectively.[36,37] Thus, infants of PND mothers are more likely to be distressed, as indicated by electrical activity in the left frontal cortex. Infant distress has a negative effect on the infant's ability to handle novel stimuli; this may in turn affect learning.[16] The negative effect of an infant's distress on learning may have a long-term influence on intellectual development.[8] Second, PND may lead to a lack of synchrony between an infant's actions and maternal responses.[9–11] Lack of synchrony between the infant and mother may have a negative effect on subsequent learning ability.[15] As such, the negative effect on learning from lack of synchrony may also have a long-term influence on intellectual development.[8]

Insignificant heterogeneity was found. Subgroup analyses indicated that the child's age at evaluation, SES, and diagnostic method of PND did not affect the mean difference in full IQ scores between the children of PND mothers and those of non-PND mothers. However, the number of each subgroup was small, and the small sample size may have caused results to be inaccurate. In addition, there were only 1 or 2 studies (Sharp et al[33] and Hay et al[19]) conducted in a socioeconomically deprived area, and those studies were from the same cohort. Also, Cogill et al[38] reported that the interaction effect of PND and SES on cognitive outcomes was marginally significant ($P = .052$). Therefore, we cannot exclude the possibility that SES affects the association between maternal PND and full IQ. In addition, although the result of the low quality group was not significantly different from that of the high quality group, the risk for the high quality group (WMD = −4.976; 95% CI, −9.273 to −0.679) was significant, and the risk for low quality (WMD = −3.516; 95% CI, −7.216 to 0.185) was not significant. Therefore, study quality might potentially affect the mean difference

in full IQ scores between the children of PND mothers and those of non-PND mothers.

This meta-analysis has some limitations. First, among the eligible studies, only 1 study[30] has a relatively large sample size. The number of the children of PND mothers and non-PND mothers was 660 and 4,369, respectively. Among other included studies, the number of the children of PND mothers ranged from 21 to 60, and the number of the children of non-PND mothers ranged from 30 to 762. Therefore, this may affect the accuracy of our conclusions.

Second, when the relationship between maternal PND and the child's IQ was explored, potential confounders such as the child's gender, birth order, presence or absence of conduct problems in the child, antenatal depression, and degree of family support needed to be considered. Antenatal depression, birth order, and family support have been reported to be associated with a child's IQ.[39–41] Although the majority of the included studies (78%) are of high quality, most studies did not adequately control for potential confounding factors. Hay et al[19] (samples from South London) adjusted for conduct problems, and Kersten-Alvarez et al[29] controlled for the child's age, gender, and the risk factors of maternal education, presence of partner conflict, separation from father, and number of stressful life events. The exposed group and the unexposed group were matched by gender in a study by Murray et al.[21] Five eligible studies included only first-born children or primiparous mothers.[20,21,30–32] However, some potential confounders were not adjusted for in some included studies. For example, the study by Milgrom et al[18] did not control for maternal or paternal IQ and antenatal depression; Hay and Kumar[31] (North London, United Kingdom) did not control for presence of a stable caregiver, family support, and selective serotonin reuptake inhibitors. Therefore, the role of maternal PND as a risk factor for the child's lower IQ may not be fully revealed in eligible studies. The association of maternal PND with the child's IQ may be affected in this meta-analysis. Prospective studies that control for various confounding factors are needed to further explore the association between maternal PND and the child's IQ. In addition, many studies found that the association between maternal PND and the child's IQ was different in boys versus girls. Some demonstrated that the association of maternal PND with the child's IQ was stronger in boys than in girls.[19,42] However, Kersten-Alvarez et al[29] had conflicting findings. Regrettably, the current evidence is not sufficient to perform a meta-analysis that separates the association between maternal PND and the child's IQ in boys versus girls.

A final but no less important limitation is that the diagnostic method of PND varied in the eligible studies. Seven articles[18–21,31–33] used a structured interview to identify PND mothers and non-PND mothers; 1 study[29] defined PND mothers according to a structured interview or the Beck Depression Inventory (cutoff ≥ 14), and 1 study[30] applied the Edinburgh Postnatal Depression Scale (cutoff > 12) to classify mothers with and without PND. Although in subgroup analysis, the result of the structured interview group was not significantly different from those of the written self-report group, the differences in grouping criteria may induce selection bias. Also, only articles written in English were included. This may have led to a language bias. Moreover, this study did not cover articles from the United States, Africa, and Asia because most of the eligible studies were performed in Europe and Oceania. In addition, the funnel plot seemed asymmetric, and the Egger test was not significant when the study by Sharp et al[33] was not included. However, the Egger test was significant when the study by Sharp et al[33] was included. Thus, publication bias may exist in our study.

CONCLUSION

According to current epidemiologic evidence, maternal PND may be a risk factor for a child's lower IQ. The child's age at evaluation and diagnostic method of PND may not affect the mean full IQ score differences between the children of PND mothers and the children of non-PND mothers. We cannot conclude whether SES affected the association between maternal PND and the child's IQ. Study quality may have potentially affected the mean full IQ score differences between the children of PND mothers and the children of non-PND mothers. Children of PND mothers may be considered a high-risk population, and interventions may be initiated to make up the negative effect of PND on the child's IQ. Future studies using large samples and better methodologies may be needed to further explore this issue.

Submitted: May 20, 2015; accepted January 11, 2016.

Online first: October 11, 2016.

Potential conflicts of interest: None reported.

Funding/support: None reported.

Acknowledgments: The authors thank Mengyao Li, PhD (China Medical University), and Ziyue Wang, PhD (China Medical University), for their help with the articles search. Drs Li and Wang report no conflicts of interest.

Supplementary material: See accompanying pages.

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Supplementary material follows this article.

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Supplementary Material

Article Title: The Long-Term Effects of Maternal Postnatal Depression on a Child's Intelligence Quotient: A Meta-Analysis of Prospective Cohort Studies Based on 974 Cases

Authors: Guoyuan Sui, PhD; Bochen Pan, PhD; Guangcong Liu, MD; Guangying Liu, MD; and Lie Wang, MD

DOI Number: 10.4088/JCP.15r10124

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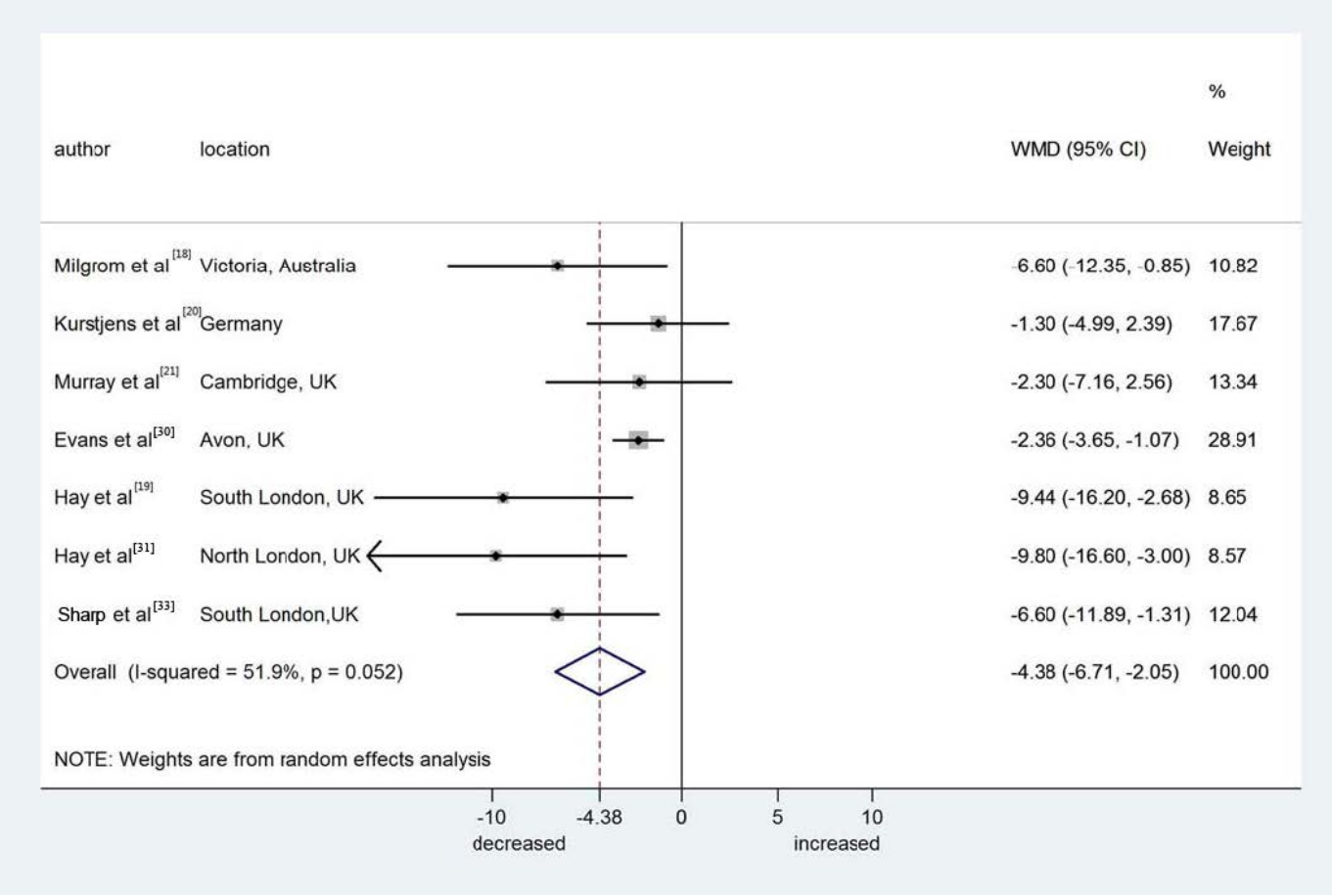
eTable 1 Ottawa quality assessment scale cohort studies

Author	1	2	3	4	5	6	7	8	Total score
Milgrom et al[18]	1	0	1	1	0	1	1	0	5
Kurstjens et al[20]	1	1	1	1	0	1	1	1	7
Murray et al[21]	1	1	1	1	1	1	1	1	8
Evans et al[30]	1	1	0	1	0	1	1	0	5
Sharp et al (South London UK)[33]	1	1	1	1	0	1	1	1	7
Hay et al (South London UK)[19]	1	1	1	1	0	1	1	1	7
Hay et al (North London UK)[31]	1	1	1	1	0	1	1	1	7
McMahon et al[32]	1	1	1	1	0	1	1	1	7
Kersten-Alvarez et al[29]	1	0	0	1	2	1	1	1	7

1.Representativeness of the exposed cohort; 2. Selection of the non-exposed cohort

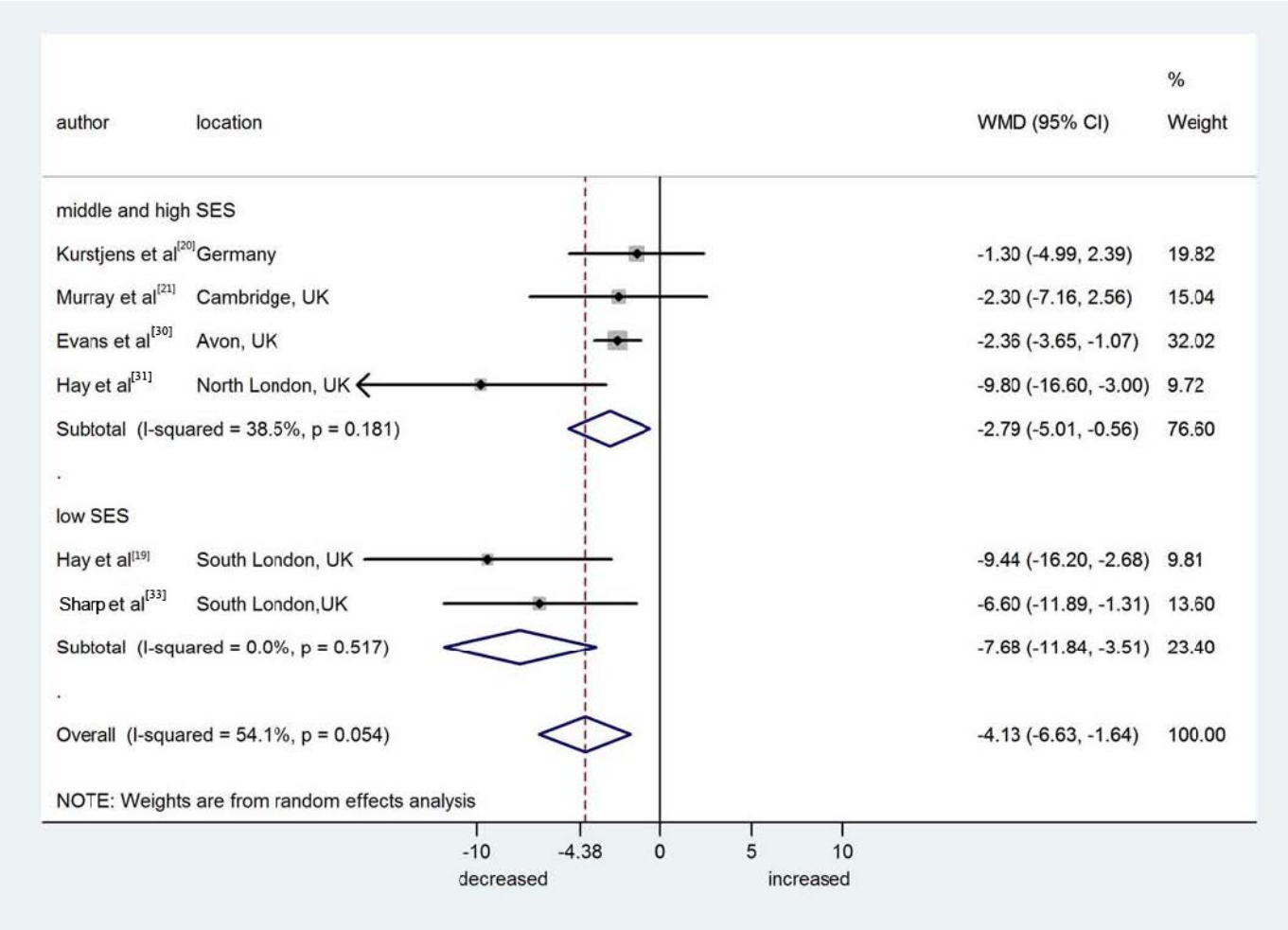
3. Ascertainment of exposure; 4. Demonstration that outcome of interest was not present at start of study; 5. Comparability of cohorts on the basis of the design or analysis; 6. Assessment of outcome; 7. Was follow-up long enough for outcomes to occur; 8. Adequacy of follow-up of cohorts

eFigure 1: Forest plot of the associations between maternal postnatal depression and full IQ among children



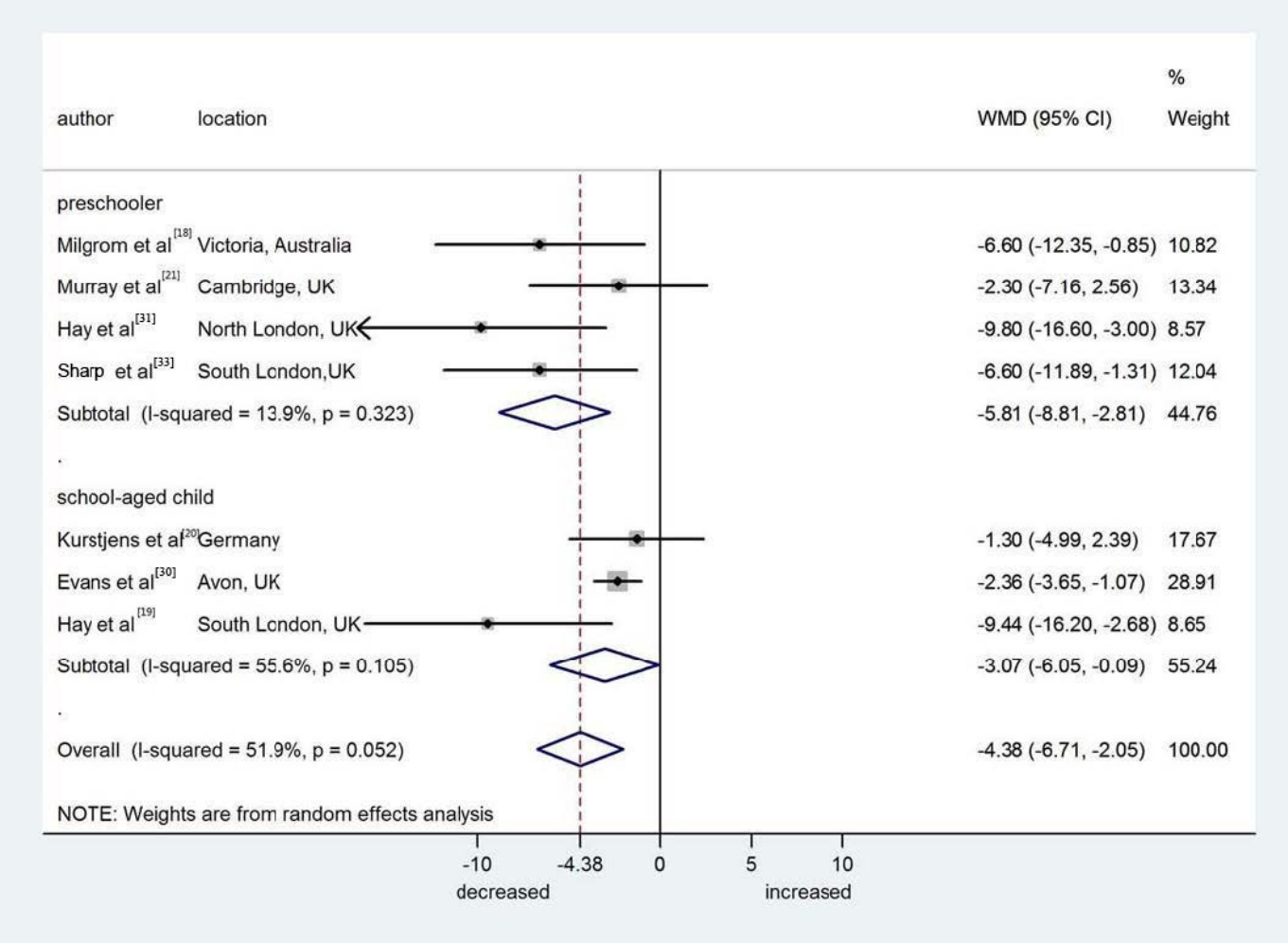
Abbreviations: IQ=intelligence quotient, WMD=weighted mean difference

eFigure 2: Associations between maternal postnatal depression and full IQ among children: subgroup analysis based on socio-economic status



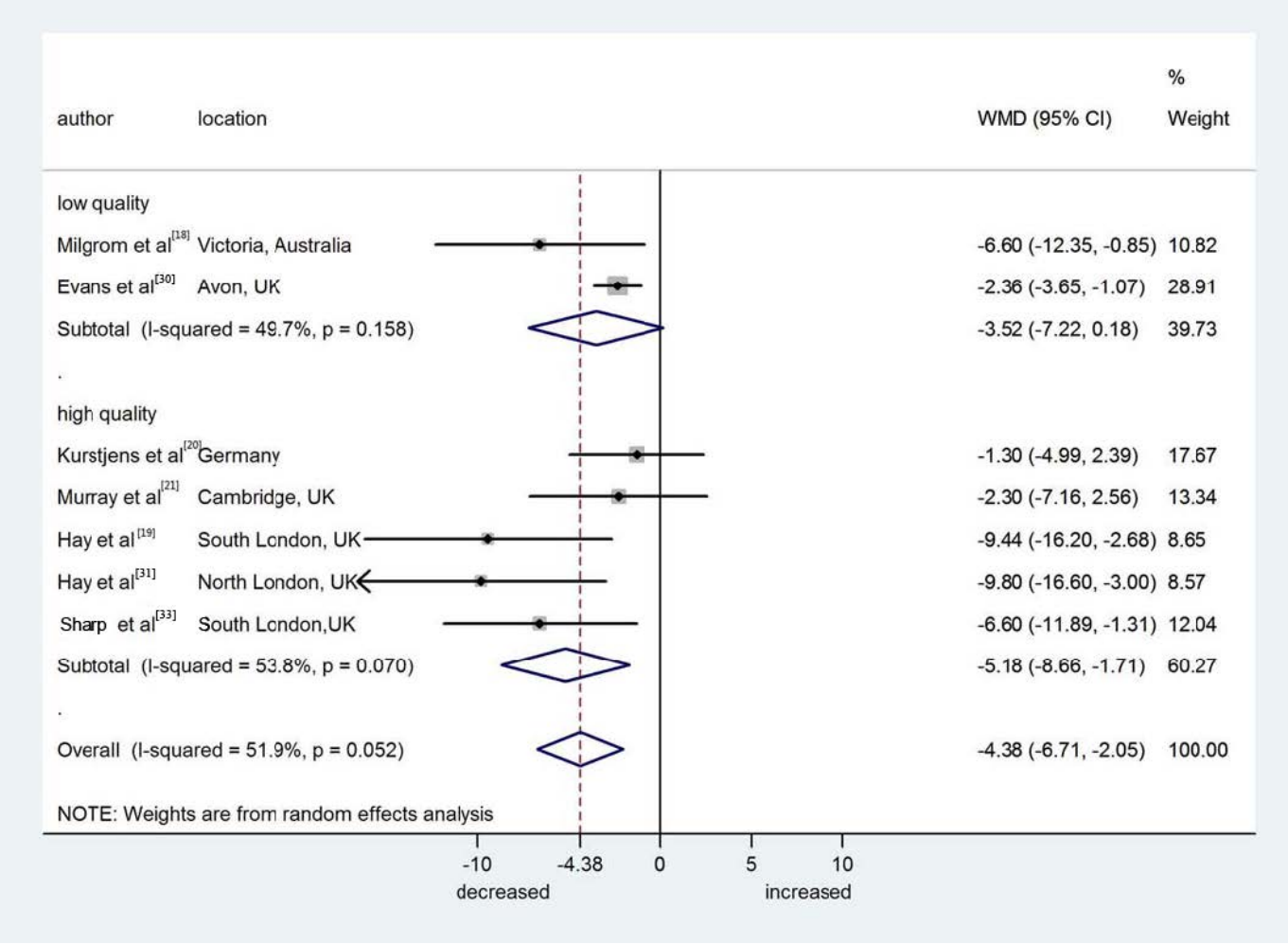
Abbreviations: IQ=intelligence quotient, SES=socioeconomic status,WMD=weighted mean difference

eFigure 3: Associations between maternal postnatal depression and full IQ among children: subgroup analysis based on child's age at evaluation



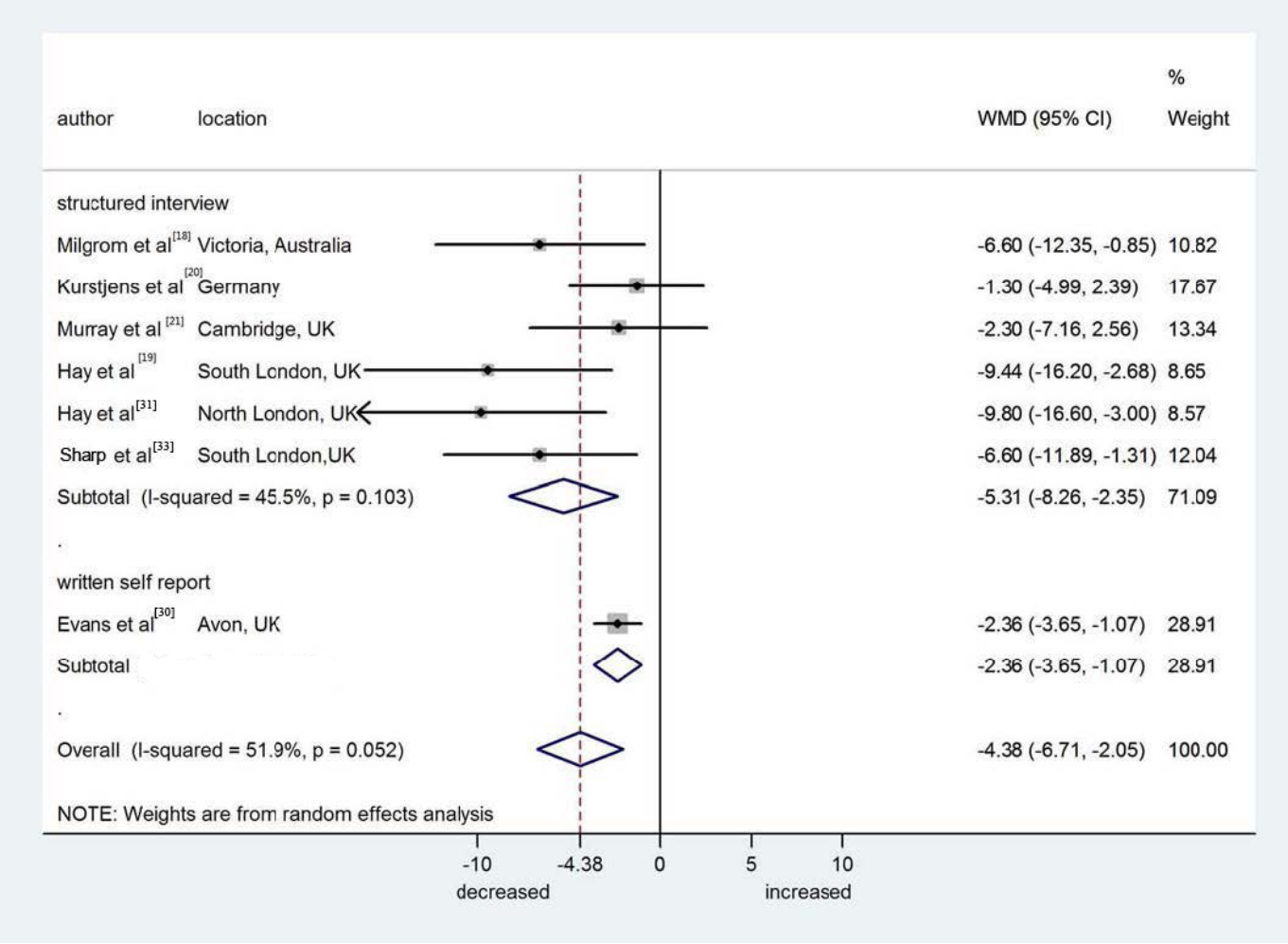
Abbreviations: IQ=intelligence quotient,WMD=weighted mean difference

eFigure 4: Associations between maternal postnatal depression and full IQ among children: subgroup analysis based on study quality



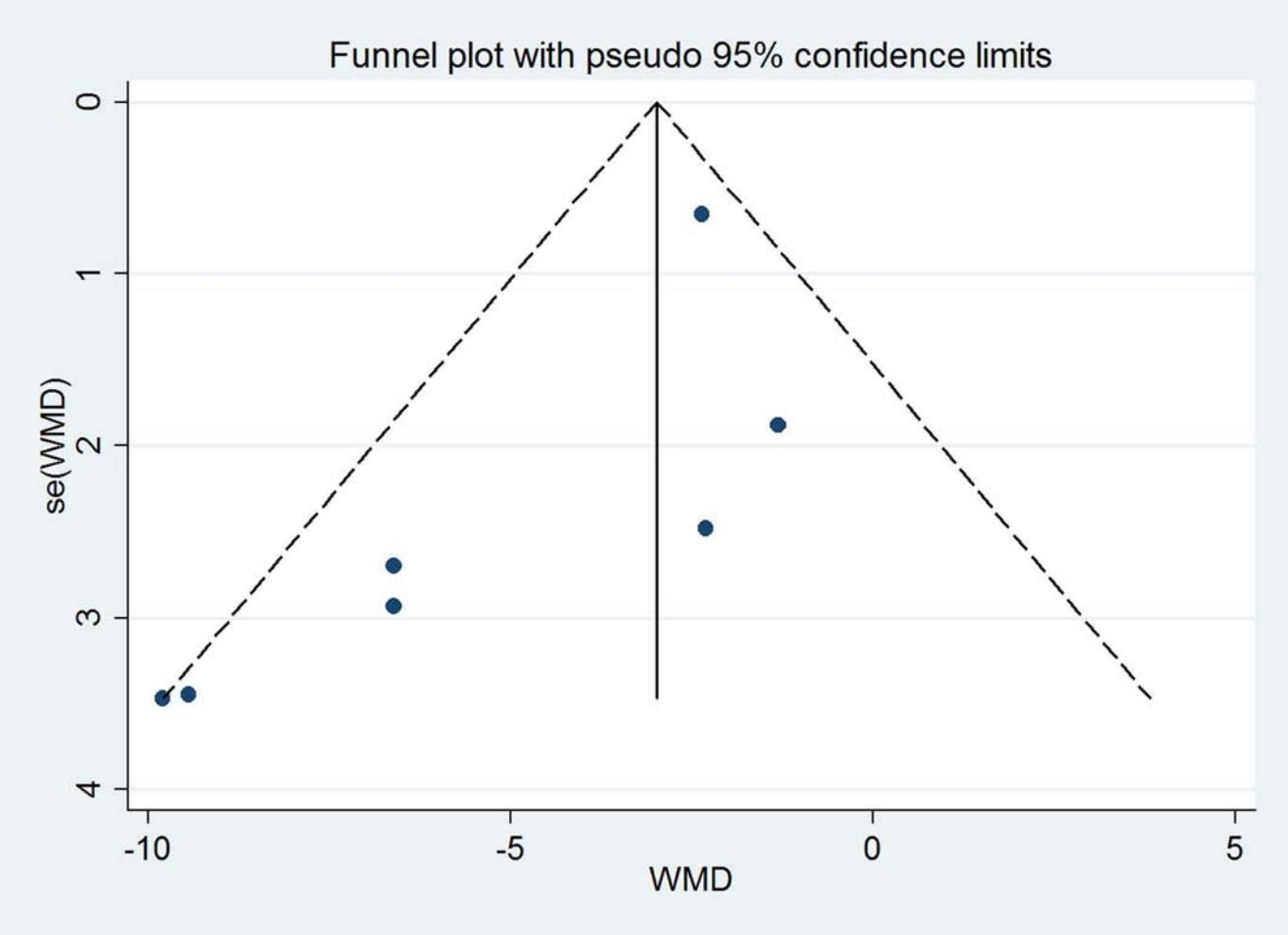
Abbreviations: IQ=intelligence quotient, WMD=weighted mean difference

eFigure 5: Associations between maternal postnatal depression and full IQ among children: subgroup analysis based on diagnostic method of postnatal depression



Abbreviations: IQ=intelligence quotient, WMD=weighted mean difference

eFigure 6: Funnel plot for eligible studies in full IQ



Abbreviations: IQ=intelligence quotient, WMD=weighted mean difference